

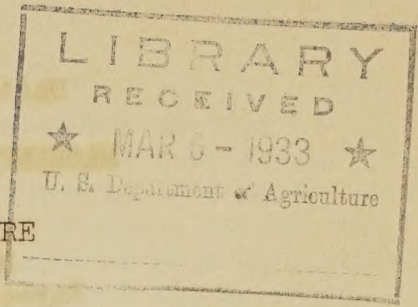
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UNITED STATES DEPARTMENT OF AGRICULTURE  
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MACHINE PLACEMENT OF FERTILIZERS APPLIED TO  
SNAP BEANS IN FLORIDA  
1931

by

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CONTENTS

	Page
Introduction .....	2
Farm practices .....	3
Reason for the study .....	3
General description of experiments .....	4
Soil types used .....	4
Experimental fertilizer placement machine .....	5
Plan of experiments .....	7
Effects of fertilizer placement on germination and stand ....	8
Effects with 5-7-5 fertilizer .....	8
Effects with 10-14-10 fertilizer .....	14
Effect of stirring soil on germination and stand .....	15
Effect of fertilizer placement on growth .....	16
Effect of fertilizer placement on yield .....	16
Summary .....	21
Literature cited .....	23

INTRODUCTION

The placement of fertilizers in relation to the position of bean seed was studied in experiments made in 1931 in the Winter Garden section of Orange County, Florida. That State produces more snap beans than any other. In 1931 there were 550 acres planted to beans in Orange County and in the entire State 13,000 acres were planted to fall beans and 24,000 acres to early spring beans.

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1/ Studies on the mechanical placement of fertilizers as affecting germination, stand and yield of snap beans in the Winter Garden section of Florida were undertaken cooperatively by the Bureau of Agricultural Engineering and the Bureau of Chemistry and Soils with the collaboration of Director Wilmon Newell of the Florida Experiment Station, who contributed helpful suggestions as to the location of the work and line of attack. Acknowledgment of the helpful cooperation of C.P. Healan, P. H. Britt, L. L. Kenneday and Kannon Brothers of Winter Garden is made, who contributed land and labor for the work.

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## Farm practices

The larger part of the bean crop in the Winter Garden section is produced in the fall. The planting covers a period of from five to six weeks beginning about August 25 and extending to October 1. The land used is almost entirely subirrigated and artificially drained. During the summer months the land is usually used to produce a crop of corn or allowed to grow up in weeds. This material is plowed under, disked and harrowed down in preparation for planting.

Planting practices vary considerably among the growers. Widths of rows vary from 30 inches to 36 inches, the closer spacings being more generally used. Seed spacing is generally about 3 inches requiring from 3 pecks to 1 bushel of seed per acre, and planting depths vary from 1 to 1-1/2 inches. The methods of applying fertilizer include the following: (a) The fertilizer is applied on the marked rows with a mechanical distributor locally known as a "Georgia Buggy," in a band about 6 inches wide. Before planting the seed, one practice is to mix the fertilizer with the soil by the use of either a "scooter" (4-inch shovel) or a 5-tooth "scratcher", while another practice is to cover the fertilizer with soil about 2 inches deep to form a slightly raised seed-bed. In these practices the opening of the fertilizer furrows and the mixing of the fertilizer with the soil are sometimes accomplished with cultivators equipped with standard shovels. (b) The fertilizer is broadcast and incorporated with the soil by disking and dragging. The seed are then drilled in rows. (c) No fertilizer is applied before or at the time of planting, but the fertilizer is applied, as a side dressing, after the plants appear above ground.

Fertilizer analyses used by the growers are generally 5-8-5, 5-5-5 and 5-7-5. Considerable castor-bean or cottonseed meal is used as well, especially in broadcast methods. From 500 to 700 pounds per acre of mixed fertilizer are usually applied at planting time and a side dressing of the same amount is generally applied two to three weeks later. Further side dressings of nitrogen and potash are used frequently later in the growing season.

Injury to seed and young plants has been frequently noted in the growing of beans in these sandy, loose soils, which is sometimes attributed to fertilizers. The greatest injury has been observed in seasons of light rainfall during the period of seed germination and in the seedling stage of the plants. Seed and plant injury attributable to fertilizer has been noted most frequently when fertilizers were used which contained large proportions of quickly soluble fertilizer salts. On the other hand, little injury has been noted when fertilizers containing large proportions of slowly available materials of animal or vegetable origin were used.

## Reason for the Study

Investigations (2) (5) of the United States Department of Agriculture have indicated that placement is an important factor in the efficient use of fertilizers for cotton and potatoes. According to the literature, placement of fertilizer may be of equal importance for a number of other crops, including beans.



Coe (1) found that applications of ammonium phosphate, analyzing 12 per cent nitrogen and 48 per cent phosphoric acid, at 25 pounds per acre to Penn loam under greenhouse conditions depressed the germination of soybeans when placed in contact with the seed and that no plants appeared with applications of 100 pounds per acre or more, while placement of fertilizers 0.5 to 1 inch to each side of the seed, at rates from 25 to 300 pounds per acre did not materially affect germination. The apparent limit of fertilizer tolerance for the germination of soy-beans was lower than that for corn, oats, barley and wheat.

Truog et al (8) in greenhouse studies have shown that 3-10-4 commercial fertilizer applied at the rate of 500 pounds per acre on Plainfield sand has a very marked retarding effect on germination of soybeans and navy beans when placed in contact with the seed but only a slight effect when placed 0.5 inch above or below the seed.

Millar and Mitchell (7) studied the influence of placement of fertilizers on white beans in the greenhouse on both Hillsdale sandy loam and Brookston loam. When placed in a band 1.5 inches wide in contact with the seed, treble superphosphate at 20 pounds per acre on the sandy loam caused some decrease in germination, while at 30 pounds per acre germination was reduced to 45 per cent. Injury to germination became significant when mono-calcium phosphate was applied at 30 or more pounds per acre and the 3-12-4 mixture at 160 pounds per acre. Superphosphate at 100 to 350 pounds per acre in contact with the seed did not materially reduce germination but only 80 per cent of the plants appeared above ground for the 350 pound rate.

On the loam soil, deterrent effects of the fertilizers were not so marked. With the fertilizer placed 0.5 inch above the seed on the sandy loam, Millar and Mitchell observed that treble superphosphate materially reduced the stand at 25 pounds per acre and no plants appeared at 100 pounds per acre, or more. The 16 per cent superphosphate placed above the seed did not have much effect on germination up to 400 pounds per acre, the maximum amount applied. Mixing the treble superphosphate with the soil to a depth of 2 inches showed no decrease in germination at 700 pounds per acre.

The prior studies with beans dealt largely with germination and early growth. Field studies carried through to maturity of the beans apparently had not been undertaken prior to those reported here-in.

#### GENERAL DESCRIPTION OF EXPERIMENTS

In the fall of 1931, cooperative field experiments in machine placement of fertilizers with green or snap beans were undertaken on the farms of P. H. Britt, L. L. Kenneday, Kannon Brothers, and C. P. Healan in the Winter Garden section of Orange County, Florida. Each experiment comprised approximately 1 acre.

#### Soil Types Used

The experiments were conducted on two types of soil, Leon fine sand and St. John's fine sand.



The Leon fine sand to a depth of 12 to 24 inches is typically a light gray to almost white fine sand which becomes medium or dark gray in color when wet. It contains little organic matter and is rather compact. Three fertilizer placement experiments were made on this soil type. The surface soil in the experiment on the Healan farm contained 1.75 per cent organic matter and had a pH of 4.6. It was less fertile than the other soils used in these experiments. The soil in the experiment on the Britt farm contained 1.74 per cent organic matter and had a pH of 5.3 and that in the experiment on the Kannon farm contained 2.03 per cent organic matter and had a pH of 5.2. The pH value of each of these soils shows them to be distinctly acid. Below the surface soil of these fields of Leon fine sand is a hardpan stratum, varying in thickness from 4 to 6 inches, consisting of a dense, compact layer of rusty brown to almost black, fine sand, high in organic matter. It is fairly impervious and may prevent the capillary rise of moisture during periods of drought. There are 149,888 acres (4) of the Leon fine sand soil type in Orange county.

A fourth fertilizer placement experiment with snap beans was made on St. John's fine sand. This type in its typical development has a surface soil of dark gray to black, rather friable, fine sand, 8 to 10 inches deep. In uncultivated areas the surface soil appears moderately compact, but as in the case of the Leon soils, it becomes looser and more incoherent with cultivation. The soil usually contains more organic matter than the Leon fine sand. The surface soil in the experiment on the Kenneday farm contained 2.41 per cent organic matter. It has a pH of 6.2, showing it to be acid. The St. John's fine sand is underlain by a compact, hardpan-like stratum of dark brown or almost black fine sand which varies in thickness on the experimental tract from 4 to 8 inches. It is high in organic matter, is hard and compact in dry weather, but softens when wet. Roots penetrate it with difficulty and during droughts it may prevent the rise of moisture from below. The subsoil is a yellowish to brownish gray fine sand similar to the lower subsoil of the Leon fine sand. There were mapped 78,400 acres of this soil type in Orange County. The soil is adapted to the same type of agriculture as the Leon fine sand. The Leon and St. John's sands are the principal types used for bean growing in the Winter Garden area.

#### Experimental Fertilizer Placement Machine

The success of a field experiment on the placement of fertilizers applied when the beans are planted depends largely on the accuracy with which the fertilizers are applied and the extent to which other conditions are controlled. Not only the amount of fertilizer and seed but depth of planting and other seed-bed conditions also must be maintained uniformly throughout the experiment.

A machine developed by the Bureau of Agricultural Engineering which simultaneously plants the seed, applies the fertilizer, and performs all necessary operations was used in this work. (Fig. 1.) The machine and attachments for obtaining the various placements were designed only for fertilizer placement experimental work. The execution of an experiment of this character requires more equipment and wider ranges of adjustment than are found or needed on commercial machines. Special equipment to



meet the varied requirements for fertilizer placement studies with beans is of necessity somewhat complicated. Doubtless the design of a machine for a specific method of applying fertilizer, as may be determined from this study, would be comparatively simple.

The experimental machine was equipped with the top-delivery type of fertilizer hopper shown at A, Figure 1, the operation of which is little affected by changes in the condition of the fertilizer. It has been found in previous studies (3) (6) that the performance of fertilizer distributors differs according to type and varies with changing conditions. Great care is necessary to accurately obtain and maintain a certain application rate of fertilizer under varying field conditions. The top delivery distributor, the operation of which has been described in other reports (6), had four delivery tubes and their length and point of attachment are such that fertilizer can be conveniently delivered to any point on the machine. The fertilizer can be delivered through one or more tubes in the amounts desired.

The machine used (Fig. 1) is of the four-wheel type and is drawn by two horses. The seed and fertilizer furrow openers and all soil working tools are mounted rigidly on a subframe, B, which can be raised and lowered without change of inclination. Thus, the position of the seed with respect to the general level of the land can be changed as desired without affecting the relative placement of fertilizer and seed. The furrowing devices for the fertilizer and the seed can not be operated independently if the most accurate relative placements are to be obtained. Furthermore, level land is essential for accurate control of the relative placements of fertilizer and seed with a machine of this type.

In these experiments it was desired that the machine place the fertilizer in a band above, in contact with, or below the seed, and in a band to each side of the seed. Provision was made for mounting a standard seed hopper either at the front of the machine for fertilizer placements above the seed, or at the rear for the other placements.

To obtain fertilizer placements in bands on each side of the seed, two single disk furrow openers were used, as shown at C, Figure 1. Bedding disks, D, throw sufficient soil in front of the seed shoe, E, to insure that all depressions are filled to permit a uniform depth of planting. Under most conditions lateral wings are attached to the seed shoe for lowering the seed bed to a constant height. A heavy, open type press wheel, F, free to exert constant pressure, covers and firms the soil about the seed.

For bands of fertilizer directly below or above the seed, cultivator shovels having shields attached to give the desired width of band were employed. (B, Fig. 2.) To mix the fertilizer with the soil below the seed, the fertilizer was first deposited in a band 3.5 inches wide, then mixed with the soil by a small stirring shovel. (C, Fig. 2.) A fertilizer delivery tube was attached at the rear of the seed shoe to place the fertilizer in contact with the seed.

In some instances residue of the previous crop and other vegetative growth had been plowed under. Where this condition is found the furrowing shovels bring a certain amount of the trash to the surface in placing the fertilizer in the deeper positions. In order to avoid difficulties from



trash collecting on the shovels when the fertilizer was placed 3 inches below the seed, it was necessary to mount a rolling coulter (A, fig. 2) in front of the shovel.

The fertilizers were in good mechanical condition and were distributed along the row with a standard deviation of about 9 per cent based on 1-foot intervals. The acre application rates in no case differed more than about 1 per cent from that desired.

#### Plan of Experiments

In each experiment 5-7-5 and 10-14-10 fertilizers were used. Their compositions are given in Table 1. Nine different placements of the 5-7-5 fertilizer and six of the 10-14-10 were studied. The various placements

Table 1.- Composition of fertilizers used

Material	Analysis				Pounds per ton	
	N	NH <sub>3</sub>	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	5-7-5 (5NH <sub>3</sub> or 4.1N)	10-14-10 (10NH <sub>3</sub> or 8.2N)
Sodium nitrate,	:	:	:	:	:	:
Arcadian	:15.9	: 19.3	-	-	: 130.0	: --
Sodium nitrate,	:	:	:	:	:	:
Chilean	:15.9	: 19.3	-	-	: -	: 130.0
Ammonium sulphate	:20.5	: 25.0	-	-	: 100.0	: 100.0
Tankage	: 8.2	: 10.0	: 3.0	-	: 250.0	: --
Fish scrap	: 8.2	: 10.0	: 6.0	-	: 250.0	: --
Superphosphate	: --	: --	: 18.0	-	: 658.0	: --
Sulphate of potash	: --	: --	: --	: 48.0	: 208.4	: 208.4
Ammono-phos	:10.7	: 13.0	:46.0	-	: -	: 304.0
Urea	:46.0	: 55.9	: --	-	: -	: 18.8
Sand	: --	: --	: --	-	: 403.6	: 238.8

of fertilizers in respect to the seed were as shown in Table 3, (page 10) except for a substitution in one placement of 10-14-10 fertilizer on the Healan farm. (See Table 2.) Each placement of fertilizer was replicated six times. Seven hundred pounds of 5-7-5 fertilizer or its equivalent of 10-14-10 fertilizer were applied at planting time and an equal amount about three weeks later as a side dressing. This made a total of 1,400 pounds of 5-7-5 or 700 pounds of 10-14-10 fertilizer per acre. Check rows planted without fertilizer were fertilized with 5-7-5 at the same rate as the other rows after the plants were up and germination data secured. Seed was planted 1.5 inches deep at the rate of 3/4 bushel per acre or approximately four seeds to the foot except in rows 12 to 15 in the experiment on the Britt farm, where the rate was only three to the foot. One-hundred foot rows were used to record data. Rows spaced 35 inches were used in the experiment on the Healan farm, and 30 inches in the other three. Bountiful Variety beans were planted. Plots with



placement of fertilizers in contact with the seed were replanted throughout all of the tests, when it became evident that the seed would not germinate, in order that the adjacent rows might not be unduly favored by the lack of competition.

## EFFECTS OF FERTILIZER PLACEMENT ON GERMINATION AND STAND

### Effects with 5-7-5 Fertilizer

The effects of fertilizers on germination when placed in different positions in relation to bean seed in four experiments are given in Tables 2, 3, 4, and 5 and are shown graphically in Figures 3, 4, 5, and 6. In columns A to I of the figures, the results of various placements of 5-7-5 fertilizer are shown, in columns I to P the results with 10-14-10 fertilizer, and in columns Q and R the results with no fertilizer.

In Experiment 1, on the Healan farm, beans were planted September 17, 1931, and germination counts made September 22 and 24 and October 1, as shown respectively by the cross hatched, plain, and solid sections in Figure 3. In Experiment 2, on the Britt farm, beans were planted on September 18 and germination counts made September 23 and 25 and October 2. In Experiment 3, on the Kenneday farm, beans were planted September 22 and germination counts made September 27 and 29 and October 5. In Experiment 4, on the Kannon farm, beans were planted September 23 and germination counts made September 28 and 30 and October 5. The rainfall records, made at Orlando, Florida, 18 miles distant, are given in Table 6, no rainfall records being available for the immediate Winter Garden section. The rainfall during the period of germination consisted of occasional light showers, and was somewhat below normal but sufficient to maintain moisture in the surface soil.

The moisture content of the soil at planting on the Healan farm was 13.2 per cent and there was no rainfall for 4 days after planting; on the Britt farm the moisture content was 11.3 per cent and no rainfall for 6 days after planting; on the Kenneday farm the moisture content of the soil was 11.5 per cent and rain of approximately 0.44 inch occurred the second day after planting. On the Kannon farm the moisture content of the soil was 15.8 per cent and there was rainfall the day of planting. There was no irrigation of the experimental fields during the period of germination and early growth.

It will be observed that germination was affected similarly, with few exceptions, in the four experiments. Considering the 5-7-5 fertilizer experiments the following facts are evident:

Where fertilizer was placed in contact with the seed, no plants appeared above ground in any of the experiments. The results are somewhat at variance where the fertilizer was placed beneath the seed. The number of plants appearing above ground at the first count where fertilizer was placed 1 inch below the seed in a band 1.75 inches wide were fewer than where no fertilizer was applied and the final stand was poorer. Appearance of plants above ground was considerably delayed when the fertilizer was placed 1 inch below the seed in bands 3.5 inches wide.



Table 2.-Number of bean plants appearing above ground per 100-foot row for various placements of fertilizers on Leon fine sand on the Healan farm, 1931. Beans planted September 17

5-7-5 fertilizer, 700 pounds per acre at planting time			
Fertilizer placement	Number of plants		
	Sept. 22	Sept. 24	Oct. 1
On surface of soil above seed	: 183 ± 13	: 280 ± 3	: 305 ± 4
In contact with seed	: 0	: 0	: 0
Mixed with soil below seed	: 85 ± 5	: 207 ± 7	: 282 ± 4
1.75-inch band 1 inch below seed	: 37 ± 7	: 148 ± 20	: 221 ± 25
1.75-inch band 3 inches below seed	: 222 ± 9	: 287 ± 6	: 308 ± 5
3.5-inch band 1 inch below seed	: 7 ± 1	: 31 ± 4	: 77 ± 8
3.5-inch band 3 inches below seed	: 200 ± 6	: 253 ± 4	: 290 ± 6
Bands 2 inches to each side 1.5 inches below level of seed	: 257 ± 12	: 339 ± 3	: 347 ± 6
Bands 4 inches to each side 1.5 inches below level of seed	: 192 ± 16	: 313 ± 4	: 332 ± 8
10-14-10 fertilizer, 350 pounds per acre at planting time			
On surface of soil above seed	: 109 ± 11	: 337 ± 6	: 346 ± 8
In contact with seed	: 0	: 0	: 0
1.75-inch band 1 inch below seed	: 5 ± 1	: 53 ± 3	: 162 ± 10
3.5-inch band 1 inch below seed	: 8 ± 4	: 63 ± 12	: 206 ± 13
Bands 2 inches to each side 1.5 inches below level of seed	: 225 ± 8	: 323 ± 3	: 354 ± 2
Bands 3 inches to each side 1.5 inches below level of seed	: 242 ± 11	: 321 ± 4	: 344 ± 5
Unfertilized checks with different soil treatment below the seed			
Soil undisturbed below the seed	: 202 ± 19	: 329 ± 3	: 354 ± 6
Soil stirred below the seed	: 202 ± 16	: 263 ± 6	: 284 ± 6
Average	: 202 ± 12	: 296 ± 7	: 319 ± 8



Table 3.- Number of bean plants appearing above ground per 100-foot row for various placements of fertilizers on Leon fine sand on the Britt farm, 1931. Beans planted September 18.

5-7-5 fertilizer, 700 pounds per acre at planting time						
Fertilizer placement	Number of plants					
	Sept. 23		Sept. 25		Oct. 2	
On surface of soil above seed	: 98	± 5	: 156	± 5	: 168	± 6
In contact with seed	: 0		: 0		: 0	
Mixed with soil below seed	: 43	± 6	: 89	± 7	: 135	± 7
1.75-inch band 1 inch below seed	: 19	± 3	: 48	± 4	: 92	± 4
1.75-inch band 3 inches below seed	: 148	± 5	: 183	± 6	: 223	± 4
3.5-inch band 1 inch below seed	: 76	± 3	: 131	± 9	: 160	± 6
3.5-inch band 3 inches below seed	: 145	± 4	: 183	± 3	: 204	± 3
Bands 2 inches to each side 1.5 inches below level of seed	: 176	± 4	: 197	± 3	: 203	± 3
Bands 4 inches to each side 1.5 inches below level of seed	: 159	± 5	: 181	± 4	: 185	± 6

10-14-10 fertilizer, 350 pounds per acre at planting time

On surface of soil above seed	: 123	± 8	: 182	± 6	: 188	± 6
In contact with seed	: 0		: 0		: 0	
Mixed with soil below seed	: 45	± 6	: 83	± 9	: 116	± 10
1.75-inch band 1 inch below seed	: 17	± 2	: 49	± 6	: 81	± 6
3.5-inch band 1 inch below seed	: 58	± 2	: 80	± 4	: 107	± 2
Bands 2 inches to each side 1.5 inches below level of seed	: 156	± 3	: 180	± 3	: 184	± 2

Unfertilized checks with different soil treatment below the seed

Soil undisturbed below the seed	: 156	± 7	: 188	± 5	: 198	± 5
Soil stirred below the seed	: 191	± 8	: 217	± 6	: 224	± 6
Average	: 174	± 6	: 202	± 5	: 211	± 4



Table 4.- Number of bean plants appearing above ground per 100-foot row for various placements of fertilizers on St. John's sand on the Kenneday farm, 1931. Beans planted September 22

5-7-5 fertilizer, 700 pounds per acre at planting time			
Fertilizer placement	Number of plants		
	Sept. 27:	Sept. 29:	Oct. 5
On surface of soil above seed	: 79 ± 10	: 240 ± 7	: 271 ± 7
In contact with seed	: 0	: 0	: 0
Mixed with soil below seed	: 60 ± 8	: 198 ± 12	: 241 ± 8
1.75-inch band 1 inch below seed	: 33 ± 4	: 151 ± 5	: 223 ± 5
1.75-inch band 3 inches below seed	: 203 ± 8	: 254 ± 8	: 283 ± 7
3.5-inch band 1 inch below seed	: 15 ± 2	: 100 ± 6	: 200 ± 3
3.5-inch band 3 inches below seed	: 205 ± 8	: 263 ± 7	: 273 ± 4
Bands 2 inches to each side 1.5 inches below level of seed	: 191 ± 11	: 283 ± 5	: 299 ± 5
Bands 4 inches to each side 1.5 inches below level of seed	: 181 ± 8	: 264 ± 6	: 281 ± 5

10-14-10 fertilizer, 350 pounds per acre at planting time

On surface of soil above seed	: 15 ± 3	: 148 ± 6	: 220 ± 7
In contact with seed	: 0	: 0	: 0
Mixed with soil below seed	: 15 ± 2	: 90 ± 10	: 194 ± 10
1.75-inch band 1 inch below seed	: 61 ± 5	: 186 ± 6	: 240 ± 5
3.5-inch band 1 inch below seed	: 36 ± 3	: 175 ± 6	: 245 ± 4
Bands 2 inches to each side 1.5 inches below level of seed	: 155 ± 11	: 245 ± 6	: 263 ± 5

Unfertilized checks with different soil treatment below the seed

Soil undisturbed below the seed	: 144 ± 12	: 245 ± 4	: 263 ± 3
Soil stirred below the seed	: 154 ± 18	: 269 ± 5	: 281 ± 7
Average	: 149 ± 11	: 257 ± 4	: 272 ± 4



Table 5.- Number of bean plants appearing above ground per 100-foot row for various placements of fertilizers on Leon fine sand on the Kannon farm, 1931. Beans planted September 23

5-7-5 fertilizer, 700 pounds per acre at planting time				
Fertilizer placement	Number of plants			
	Sept. 28	Sept. 30	Oct. 5	
On surface of soil above seed	153 ± 8	335 ± 5	348 ± 3	
In contact with seed	0	0	0	
Mixed with soil below seed	66 ± 5	208 ± 7	280 ± 5	
1.75-inch band 1 inch below seed	21 ± 3	138 ± 9	236 ± 6	
1.75-inch band 3 inches below seed	216 ± 8	280 ± 12	276 ± 12	
3.5-inch band 1 inch below seed	58 ± 6	201 ± 14	264 ± 12	
3.5-inch band 3 inches below seed	240 ± 3	328 ± 5	325 ± 4	
Bands 2 inches to each side 1.5 inches below level of seed	244 ± 7	310 ± 4	316 ± 6	
Bands 4 inches to each side 1.5 inches below level of seed	226 ± 6	350 ± 4	351 ± 6	

10-14-10 fertilizer, 350 pounds per acre at planting time

On surface of soil above seed	50 ± 6	269 ± 7	346 ± 4
In contact with seed	0	0	0
Mixed with soil below seed	69 ± 17	174 ± 21	249 ± 18
1.75-inch band 1 inch below seed	10 ± 1	79 ± 7	169 ± 10
3.5-inch band 1 inch below seed	40 ± 5	208 ± 12	299 ± 7
Bands 2 inches to each side 1.5 inches below level of seed	268 ± 9	353 ± 4	359 ± 7

Unfertilized checks with different soil treatment below the seed

Soil undisturbed below the seed	241 ± 6	325 ± 5	324 ± 3
Soil stirred below the seed	164 ± 6	291 ± 3	295 ± 4
Average	202 ± 8	308 ± 4	310 ± 4



Table 6.- Rainfall at Orlando, Fla. during the germination period for beans - September to November, 1931

Date	September	October	November
1	0.04	0.00	0.00
2	Trace	.07	.00
3	.00	.00	.00
4	.80	.18	.00
5	.00	.01	.00
6	.30	.45	.00
7	.00	.08	.00
8	.57	Trace	.00
9	.10	.07	.00
10	.00	.00	.00
11	Trace	.00	.00
12	.18	.00	.00
13	.00	.13	.00
14	.63	.07	.00
15	.07	.02	.00
16	Trace	Trace	.00
17	.00	.00	.00
18	.00	.00	.00
19	.00	.15	.00
20	.00	.00	.09
21	.00	Trace	.00
22	.00	.00	.03
23	.44	.00	.01
24	.07	.00	.00
25	Trace	.00	.00
26	.00	.00	.00
27	.23	.00	.00
28	.00	.00	.00
29	.11	.07	.00
30	.14	.00	.00
31	--	.00	--
Total	3.72	1.30	0.13



The stand for the 1-inch depth was such in some of the experiments that many growers would have plowed up the beans and replanted. There was no delay in the appearance of the plants above ground where the fertilizer was placed 3 inches below the seed in bands 1.75 inches and 3.5 inches wide. Plants appeared above ground as early and, in some cases, more rapidly than on the unfertilized rows. The appearance of plants above ground was delayed, but the final stand was good in most of the experiments when the fertilizer was mixed with the soil below the seed.

Application of fertilizer above the seed caused delay in appearance of the plants above the ground in the experiments on the Britt and Kenneday farms, but practically no delay in the experiments on the Healan and Kannon farms. Doubtless the amount of moisture and distribution of rainfall largely determined the deterrent effects of the fertilizer when placed above the seed. There was some burning of the young plants at the surface of the ground in all the experiments. However, most of the plants survived and the final stand was good.

Satisfactory stands were obtained in all cases where the fertilizer was applied below the level of the seed, in narrow bands at different distances to the sides of the seed. No delay in appearance of the plants above ground was observed and in most cases plants appeared above the ground more rapidly than on the unfertilized rows. The effects of some of the placements of the 5-7-5 fertilizer on appearance of the plants above ground and on stand in the field one week after planting are shown in Figure 7. In Figure 8 are typical plants dug from the field plots, showing the development of plants when fertilizer was placed to the sides of the seed, below the seed, and in contact with the seed.

#### Effects with 10-14-10 Fertilizer

Results secured where 10-14-10 fertilizer was applied in amounts equivalent in plant food content to 5-7-5 fertilizer, were somewhat similar to those just stated (See Tables 2 to 5 and Figures 3 to 6.) The appearance of plants above ground was delayed and the stand unsatisfactory when the fertilizer was placed 1 inch below the seed in bands 1.75 inches wide and in bands 3.5 inches wide. There was also delay in appearance of plants above ground and unsatisfactory stand when the fertilizer was placed below the seed and mixed with the soil. In one of the experiments, the delay in appearance of plants above ground was greater with the 10-14-10 fertilizer than with the 5-7-5 fertilizer.

Where the fertilizer was applied on the surface of the ground above the seed, delay in appearance of plants above ground was observed, but final stands compared favorably with the unfertilized rows. Some burning of the plants as they pushed through the soil was noticed and a somewhat stunted growth prevailed for a few days. This burning was more serious than with the 5-7-5 fertilizer and the appearance of the plants above ground was more retarded in three of the experiments.

When this concentrated fertilizer was applied 1.5 inches below the level of the seed and 2 or 3 inches to each side of the seed satisfactory stands were obtained and the appearance of plants above ground was as rapid as where no fertilizer was used. The stands of young plants resulting from various placements of 10-14-10 fertilizer are shown in Figure 9.



Summarizing the data from each of the four experiments, it is apparent that severe injury to germination as measured by the number of plants appearing above ground occurred in all cases when either the 5-7-5 or 10-14-10 fertilizer was placed in immediate contact with the seed. The placement of the fertilizer in either a narrow or wide band 1 inch under the seed resulted in reduced stands, as did the placement of fertilizer below the seed and mixing it with the soil. Germination as measured by the number of plants appearing above ground was variable when either the single-strength or double-strength fertilizer was applied on the surface of the soil above the seed. Considerable delay in the appearance of plants above ground occurred but the final stand was good. The leaves of the young plants were injured as the plant came through the surface of the soil, which was more severe when the 10-14-10 fertilizer was used. Satisfactory stands were obtained at all depths and distances from the seed when the fertilizer was applied at the sides of the seed. The application of single and double strength fertilizer resulted in no appreciable difference in the rapidity of appearance of plants above ground and in stand when the fertilizer was placed to the sides of the seed. Applying the fertilizer in bands at the sides of the seed, in addition to the fact that so located there is probably less movement of soluble fertilizer salts in the direction of the seed, offers the advantage of planting the seed in undisturbed soil.

#### EFFECTS OF STIRRING SOIL ON GERMINATION AND STAND

In two treatments the bean seed was planted without fertilizers. (See Tables 2 to 5 and Figures 3 to 6.) In one case the soil below the seed was undisturbed and in the second the soil below the seed was stirred. In obtaining the various placements of the fertilizers directly below the seed, it was necessary to disturb the soil but for placements in contact with, above, or to the sides of the seed, the soil was not disturbed below the seed at time of planting. For purposes of making certain direct comparisons with an appropriate unfertilized check, particularly with regard to germination, it was believed advisable to treat the soil as indicated above. However, disturbing of the soil below the seed is necessary in obtaining certain placements of the fertilizer, and unless there is some practical means of correcting this condition it is doubtful if cognizance should be taken of this factor<sup>in</sup> considering the influence of fertilizer placement.

In the experiment on the Healan farm, as shown in Table 2, the number of plants above ground five days after planting was the same, but the final come-up was greater where the soil was undisturbed below the seed. In all cases, the seed was covered with a heavy press wheel which packed the soil to a considerable extent around the seed, and disturbing the soil below the seed as accomplished in these tests is not believed to have materially influenced the results. Furthermore, where rains follow immediately after planting any differences in the condition of the soil about the seed are largely eliminated. Where the soil has been stirred, if no rain occurs immediately after planting, insufficient moisture would doubtless reach the seed and germination would be greatly influenced.



In the other experiments, Tables 3, 4, and 5, differences in the stands for the two unfertilized checks are not highly significant. In one case a few more plants appeared with the undisturbed treatment, while in the other two cases more plants appeared when the soil was stirred. An average of these two treatments is given in the tables so that comparisons of fertilizer placements may be made with the average or with either of the no-fertilizer plots.

It is not believed that, under the conditions of this study, disturbing the soil under the seed at time of planting, in certain treatments previously mentioned, had any significant effect on the yields.

#### EFFECT OF FERTILIZER PLACEMENT ON GROWTH

The placement of fertilizers in relation to bean seed also influenced the growth of plants. Marked differences were noted during the first three weeks following the appearance of the bean plants above ground. The relative growth of beans with different placements of 5-7-5 fertilizer three weeks after the plants emerged above the surface of the ground is shown in Figure 10, and of 5-7-5 and 10-14-10 in Figure 11. It is apparent that placement of the fertilizer 3 inches below the seed gave a better growth than when it was placed 1 inch below the seed, or where the fertilizer was mixed with the soil and seed planted above the fertilizer.

The relative growth of beans at blooming time for different placements of 5-7-5 fertilizer is shown in Figure 12 and for 10-14-10 fertilizer in Figure 13. When fertilizer was applied 7 days after the seed was planted and none before planting, a good stand of plants was obtained but the growth was delayed and the plants were small at blooming time as shown in Figure 12. At this stage of the plant's development, large plants are found where fertilizers were applied to the sides of the seed. The smaller growth produced by the 10-14-10 fertilizer when placed 1 inch below the seed as compared to growth of plants where the fertilizer was placed to the sides of the seed is shown in Figure 13.

#### EFFECT OF FERTILIZER PLACEMENT ON YIELD

The yield of snap beans in the four experiments is given in Tables 7 to 10, and graphically in Figures 3 to 6. The trend of the yields from fertilizers placed differently in relation to the seed correlates in a general way with the germination and stand data, although there are some interesting variations.

Placement of 5-7-5 fertilizers in bands of different widths 3 inches below the seed and placement to the sides of the seed gave largest yields of beans at the first picking and in most instances larger total yields than other placements in each of the four experiments. There was a great difference in yield at the first picking from these placements of fertilizer. The differences in total yield were not so wide, which is indicative of a slower growth and blooming of the plants where fertilizers were placed in the less favorable positions. No yields are recorded from the placement of fertilizers in contact with seed, as the first seed planted in these rows



Table 7.- Yield of green beans for various fertilizer placements on Leon fine sand on Healan farm, 1931

Fertilizer placement	Yield				
	Oct. 31		Nov. 5		Total
	Pounds:	p. acre:	Pounds:	p. acre:	
5-7-5 fertilizer, 700 pounds per acre at planting time and 700 pounds per acre side dressed October 7					
On surface of soil above seed	1,415	997	972	402	3,786 + 394: 114.7
In contact with seed	0	0	0	0	0
Mixed with soil below seed	978	1,345	1,148	576	4,047 + 330: 122.6
1.75-inch band 1 inch below seed	901	1,347	1,179	506	3,933 + 540: 119.2
1.75-inch band 3 inches below seed	1,818	1,362	1,086	537	4,803 + 390: 145.5
3.5-inch band 1 inch below seed	132	452	534	284	1,402 + 194: 42.5
3.5-inch band 3 inches below seed	1,616	1,013	1,221	423	4,233 + 365: 129.8
Bands 2 in. to each side 1.5 in. below level of seed	1,500	1,019	1,155	376	4,050 + 462: 122.7
Bands 4 in. to each side 1.5 in. below level of seed	1,271	1,172	946	354	3,743 + 440: 113.4
10-14-10 fertilizer, 350 pounds per acre at planting time and 350 pounds per acre side dressed October 7					
On surface of soil above seed	970	1,304	1,034	420	3,778 + 406: 114.5
In contact with seed	0	0	0	0	0
1.75-inch band 1 inch below seed	93	587	804	414	1,898 + 281: 57.5
3.5-inch band 1 inch below seed	85	534	850	532	2,051 + 288: 62.2
Bands 2 in. to each side 1.5 in. below level of seed	1,182	1,262	1,114	379	3,937 + 373: 119.3
Bands 3 in. to each side 1.5 in. below level of seed	1,473	1,107	1,041	395	4,016 + 468: 121.7
Unfertilized at planting, September 17; 5-7-5 fertilizer side dressed, 700 pounds per acre September 24 and 700 pounds per acre October 7					
Soil undisturbed below the seed	692	846	596	252	2,386 + 305: 72.3
Soil stirred below the seed	1,205	774	834	299	3,162 + 189: 95.8
Average	943	810	740	276	2,774 + 193: 84.

Table 8.- Yield of green beans for various fertilizer placements on Leon fine sand on Britt farm, 1931

Fertilizer placement	Yield				
	Nov. 3	Nov. 6	Nov. 10	Nov. 14	Total
	Pounds : p. acre :	Pounds : p. acre :	Pounds : p. acre :	Pounds : p. acre :	Pounds : p. acre :
5-7-5 fertilizer, 700 pounds per acre at planting time and 700 pounds per acre side dressed October 12					
On surface of soil above seed	1,756	1,072	1,236	862	4,926 ± 134
In contact with seed	0	0	0	0	0
Mixed with soil below seed	1,195	1,373	1,437	1,275	5,280 ± 140
1.75-inch band 1 inch below seed	555	721	1,169	874	3,319 ± 136
1.75-inch band 3 inches below seed	2,620	1,173	1,672	1,205	6,670 ± 210
3.5-inch band 1 inch below seed	1,704	1,161	1,705	1,102	5,672 ± 211
3.5-inch band 3 inches below seed	2,563	1,595	1,359	1,091	6,613 ± 200
Bands 2 in. to each side 1.5 in. below level of seed	3,216	1,400	1,376	803	6,795 ± 247
Bands 4 in. to each side 1.5 in. below level of seed	3,269	1,302	1,435	1,075	7,081 ± 134
10-14-10 fertilizer, 350 pounds per acre at planting time and 350 pounds per acre side dressed October 12					
On surface of soil above seed	2,446	1,259	1,329	1,046	6,080 ± 117
In contact with seed	0	0	0	0	0
Mixed with soil below seed	833	1,262	1,320	1,076	4,491 ± 308
1.75-inch band 1 inch below seed	820	864	1,031	928	3,643 ± 402
3.5-inch band 1 inch below seed	850	990	1,123	879	3,842 ± 250
Bands 2 in. to each side 1.5 in. below level of seed	3,071	1,333	1,275	857	6,541 ± 240
Unfertilized at planting, September 18; 5-7-5 fertilizer side dressed, 700 pounds per acre September 25 and 700 pounds per acre October 12					
Soil undisturbed below the seed	1,598	1,193	1,046	713	4,550 ± 162
Soil stirred below the seed	1,945	1,240	1,335	719	5,239 ± 154
Average	1,771	1,217	1,190	716	4,594 ± 130



Table 9.- Yield of green beans for various fertilizer placements on St. Johns sand on Kennedy farm, 1931

5-7-5 fertilizer, 700 pounds per acre at planting time and 700 pounds per acre side dressed October 13													
Fertilizer placement		Yield											
		Nov. 9		Nov. 13		Nov. 16		Nov. 19		Nov. 23		Total	
		Pounds		Pounds		Pounds		Pounds		Pounds		Pounds	
		p. acre		p. acre		p. acre		p. acre		p. acre		p. acre	
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Table 10.- Yield of green beans for various fertilizer placements on Leon fine sand on Kannon farm, 1931

Fertilizer placement	Yield				
	Nov. 10:	Nov. 13:	Nov. 16:	Nov. 19:	Total
	Pounds:	Pounds:	Pounds:	Pounds:	Pounds:
	p.acre:	p.acre:	p.acre:	p.acre:	p.acre:
5-7-5 fertilizer, 700 pounds per acre at planting time and 700 pounds per acre side dressed October 15					
On surface of soil above seed	2,549	2,731	1,167	866	7,313 ± 288
In contact with seed	0	0	0	0	0
Mixed with soil below seed	2,402	1,769	1,669	1,278	7,118 ± 213
1.75-inch band 1 inch below seed	2,183	1,600	1,952	1,180	6,915 ± 120
1.75-inch band 3 inches below seed	3,364	1,792	1,687	911	7,754 ± 227
3.5-inch band 1 inch below seed	2,484	1,835	1,566	1,010	6,945 ± 202
3.5-inch band 3 inches below seed	3,256	1,508	1,464	1,022	7,250 ± 223
Bands 2 in. to each side 1.5 in. below level of seed	3,410	1,353	1,285	1,135	7,183 ± 161
Bands 4 in. to each side 1.5 in. below level of seed	3,191	1,442	1,200	664	6,497 ± 261
10-14-10 fertilizer, 350 pounds per acre at planting time and 350 pounds per acre side dressed October 15					
On surface of soil above seed	2,042	1,936	1,557	875	6,410 ± 260
In contact with seed	0	0	0	0	0
Mixed with soil below seed	1,768	2,339	1,424	922	6,453 ± 348
1.75-inch band 1 inch below seed	1,358	1,743	1,732	1,026	5,864 ± 229
3.5-inch band 1 inch below seed	1,788	2,201	1,806	1,154	6,949 ± 243
Bands 2 in. to each side 1.5 in. below level of seed	3,299	2,556	1,670	902	8,427 ± 370
Unfertilized at planting, September 23; 5-7-5 fertilizer side dressed, 700 pounds per acre September 30 and 700 pounds per acre October 15					
Soil undisturbed below the seed	2,623	1,872	1,043	1,195	6,643 ± 262
Soil stirred below the seed	3,285	1,308	1,284	853	6,730 ± 194
Average	2,954	1,590	1,164	979	6,687 ± 165



did not come up. Smaller yields generally resulted from placement of fertilizers 1 inch below the seed and from fertilizer mixed with soil below the seed. The placement of fertilizers on the surface of the soil above the seed gave good yields, but the yields at the first pickings were not as great as from the placement of fertilizers to the sides of the seed or 3 inches below the seed.

The 10-14-10 fertilizer placed to the side of the seed gave largest total yields of green beans and largest yield at first picking of any other placement used, which correlates with the germination and stand data. Fertilizer applied on the surface of the soil above the seed gave larger yields at the first picking in all but one of the experiments than did the fertilizer applied 1 inch below the seed but the total yields in two of the experiments were largest where fertilizers were placed below the seed.

Where the fertilizers were applied after the plants were up the yields are generally lower as compared to yields from at-planting applications, except where the fertilizer placements resulted in delayed germination and poorer stands. Some exceptions are noted in the experiment on the Kannon farm, where the yields from some of the at-planting applications are smaller than from the delayed applications.

Fertilizers placed in a band to each side of the seed, and in a band 3 inches below the seed produced the highest yields. Placing the fertilizer in bands 1 inch below the seed, irrespective of the width of the bands or analysis of the fertilizer gave poorer yields throughout the experiments, especially at the first picking. Mixing of the fertilizer in the soil below the seed or applying it on the surface of the soil above the seed gave smaller yields than fertilizer applied to the sides of the seed.

#### SUMMARY

In three experiments with machine application of fertilizers on Leon fine sand and one on St. John's fine sand in the Winter Garden section of Orange County, Florida, green or snap beans failed to come up when 700 pounds per acre of a 5-7-5 fertilizer or 350 pounds per acre of a 10-14-10 fertilizer were applied in contact with the seed. Where these fertilizers were applied 1 inch below the seed in bands 1.75 or 3.5 inches wide, germination of seed, as evidenced by appearance of plants above ground, was delayed or stands were poor. Fertilizer mixed in the soil under the seed delayed the appearance of the plants above ground and caused poor stands. Where fertilizers were applied 2 or 4 inches to the sides of and 1.5 inches below the level of the seed, and where fertilizers were applied 3 inches directly below the seed in wide and narrow bands, plants appeared above ground as rapidly and in as large numbers as on unfertilized rows.

Throughout the experiments as a whole there was only a slight difference in germination and stand when 5-7-5 and 10-14-10 fertilizers were used in equivalent plant-food quantities. When either of the fertilizers was applied to the sides of and 1.5 inches below the level

of the seed, the appearance of plants above ground was normal as compared to stands obtained with no fertilizer. With these placements the double strength fertilizer was as favorable as the single strength. Where the fertilizer was placed in a narrow band 1 inch below the seed, was mixed with the soil below the seed, or was applied on the surface of the ground above the seed, the effects from the 10-14-10 fertilizer were slightly less favorable than from the 5-7-5 fertilizer. Burning of the leaves of the young plants occurred when the more concentrated fertilizer was placed on the surface of the soil above the seed.

The fertilizer placements which retarded the appearance of plants above the surface of the soil, also retarded the growth of the plants during the first three weeks, and delayed blooming of the plants and setting of beans.

The yield of beans also was influenced by the placement of the fertilizer. Both highest total yields and largest yields at the early picking generally were obtained where the fertilizers were placed in a band on each side of the seed 1.5 inches below the seed level and in a band 3 inches under the seed. Placing the fertilizers 1 inch below the seed, irrespective of the width of the band or of the analysis of the fertilizer gave poor yields and late maturing beans. Application of fertilizers on the surface of the soil above the seed gave good yields but the setting of beans was delayed, as evidenced by the low yield at first pickings.

In general, best stands of plants, most rapid growth, earliest blooming and setting of beans and largest yields were secured when the fertilizer was placed in a band either 2 or 4 inches to each side of the seed, and in a band 3 inches directly below the seed.

The results given in this report are for one year only, and final conclusions should await completion of the experiments which are still in progress.



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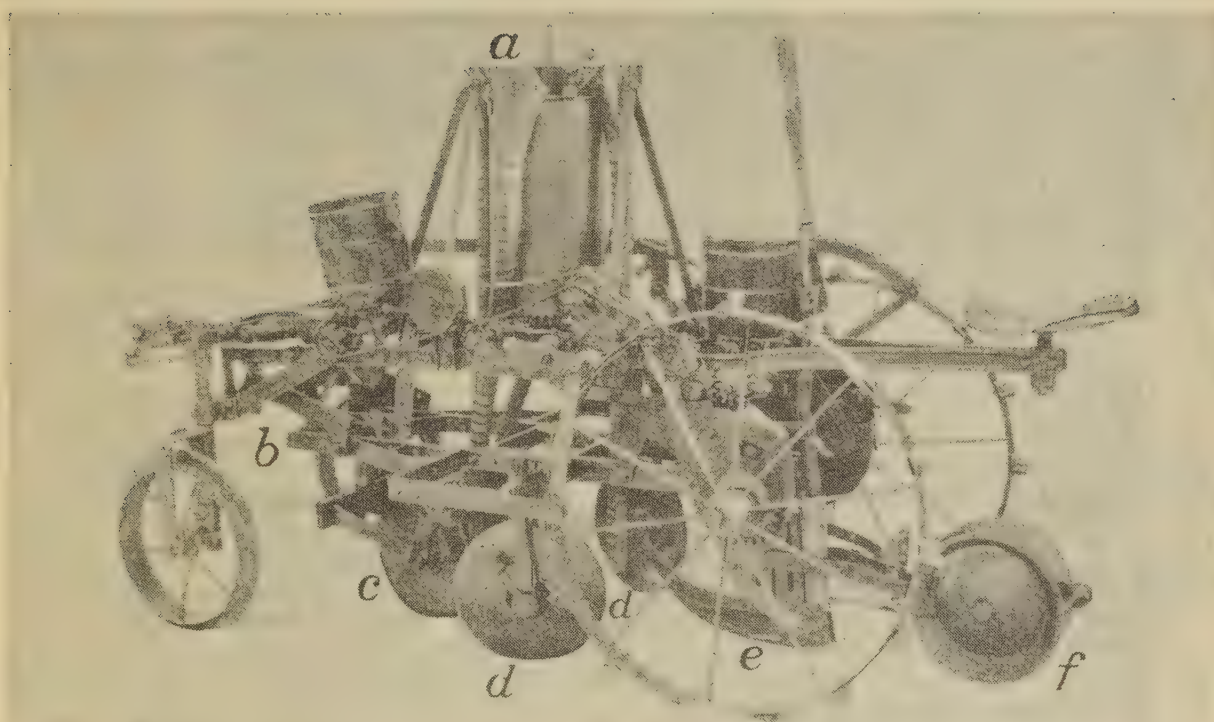


Figure 1.- Special combination planter and fertilizer distributor built under the general specifications of the Bureau of Agricultural Engineering for fertilizer placement experiments with truck crops: a, top-delivery type of fertilizer hopper; b, sub-frame for holding the soil-working tools; c, single disk furrow openers for placing the fertilizer at the sides of the seed; d, bedding disks; e, seed shoe; f, press wheel

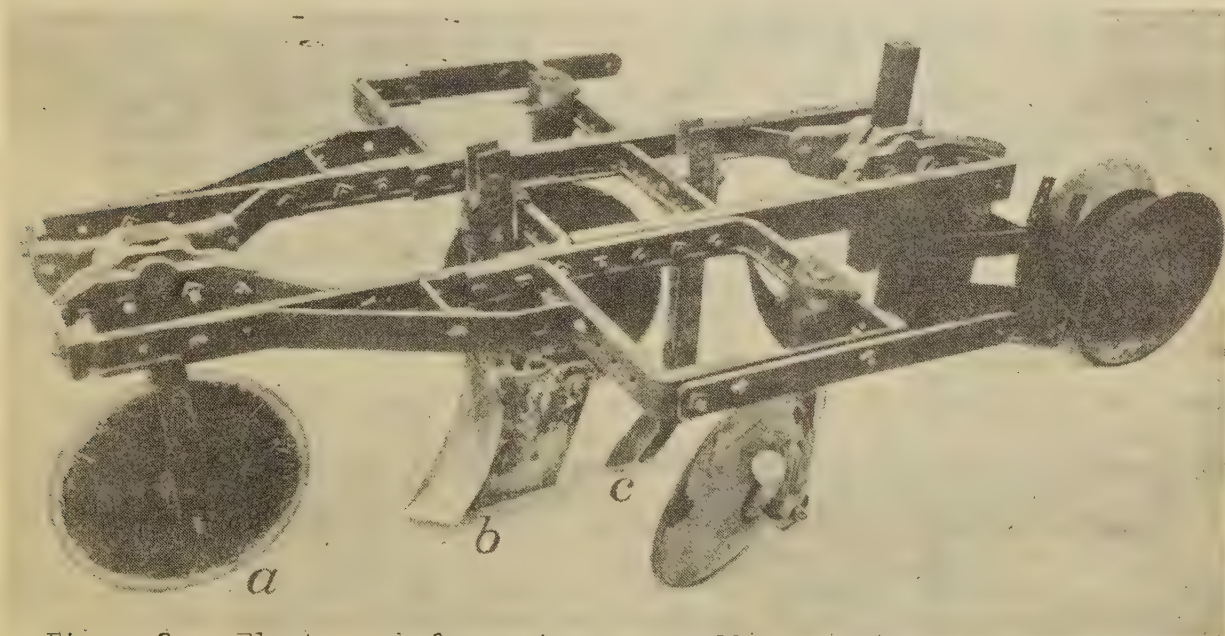


Figure 2.- Planter sub-frame showing a rolling coulter, a, for cutting trash, a special shovel, b, for placing the fertilizer in a band of uniform width below the seed, and a mixing shovel, c, for mixing the fertilizer with the soil below the seed

Figures 3, 4, 5, 6.- Effect of Fertilizer Placement on Germination and Stand and on Yield of Snap Beans

Stand shown by count of plants on three dates, - first count by hatched section of column; increases in second and third counts by plain and solid sections, respectively; maximum stand by total height of column.

Yield shown for separate pickings, - first picking by close-hatched section of column; final picking by solid section; intermediate pickings by plain, wide-hatched, and dotted sections in order; total yield by total height of column.

Fertilizer placements:

5-7-5 fertilizer, 700 pounds per acre at planting and 700 pounds per acre as side dressing -

On ground surface above seed ..... A

In contact with seed ..... B

Mixed with soil below seed ..... C

1.75-inch band 1 inch below seed ..... D

3.50-inch band 1 inch below seed ..... E

1.75-inch band 3 inches below seed ..... F

3.50-inch band 3 inches below seed ..... G

Bands 2 inches to each side, 1.5 inches below level of seed .... H

Bands 4 inches to each side, 1.5 inches below level of seed .... I

10-14-10 fertilizer, 350 pounds per acre at planting and 350 pounds per acre as side dressing -

On ground surface above seed ..... J

In contact with seed ..... K

Mixed with soil below seed ..... L

1.50-inch band 1 inch below seed ..... M

3.50-inch band 1 inch below seed ..... N

Bands 2 inches to each side, 1.5 inches below level of seed .... O

Bands 3 inches to each side, 1.5 inches below level of seed .... P

No fertilizer at planting; two side dressings, each 700 pounds per acre of

5-7-5 fertilizer -

Soil stirred below seed ..... Q

Soil not disturbed below seed ..... R

Figure 3.- Experiment 1, Leon fine sand on Healan farm. Seed planted Sept. 17.

Stand: first count Sept. 22, second count Sept. 24, third count Oct. 1.

Yield: first picking Oct. 31, second picking Nov. 5, third picking Nov. 10, fourth picking Nov. 14.

Figure 4.- Experiment 2, Leon fine sand on Britt farm. Seed planted Sept. 18.

Stand: first count Sept. 23, second count Sept. 25, third count Oct. 2.

Yield: first picking Nov. 3, second picking Nov. 6, third picking Nov. 10, fourth picking Nov. 14.

Figure 5.- Experiment 3, St. John's fine sand on Kenneday farm. Seed planted Sept. 22.

Stand: first count Sept. 27, second count Sept. 29, third count Oct. 5.

Yield: first picking Nov. 9, second picking Nov. 13, third picking Nov. 16, fourth picking Nov. 19, fifth picking Nov. 23.

Figure 6.- Experiment 4, Leon fine sand on Kannon farm. Seed planted Sept. 23.

Stand: first count Sept. 28, second count Sept. 30, third count Oct. 5.

Yield: first picking Nov. 10, second picking Nov. 13, third picking Nov. 16, fourth picking Nov. 19.



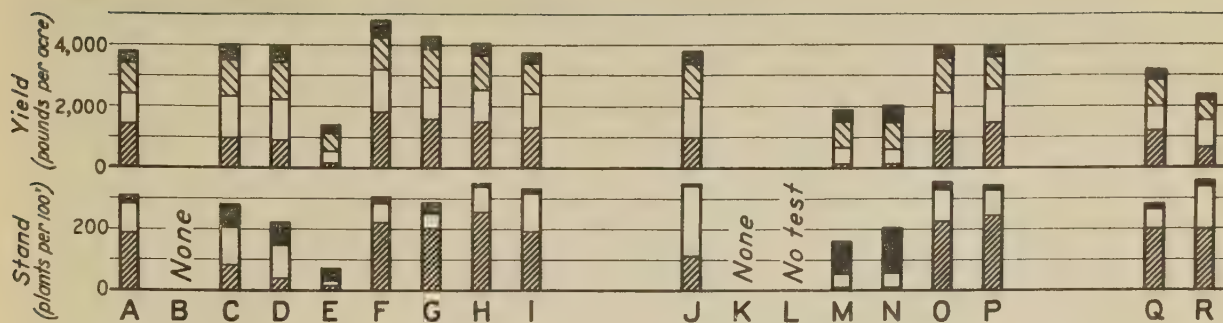


Fig.3

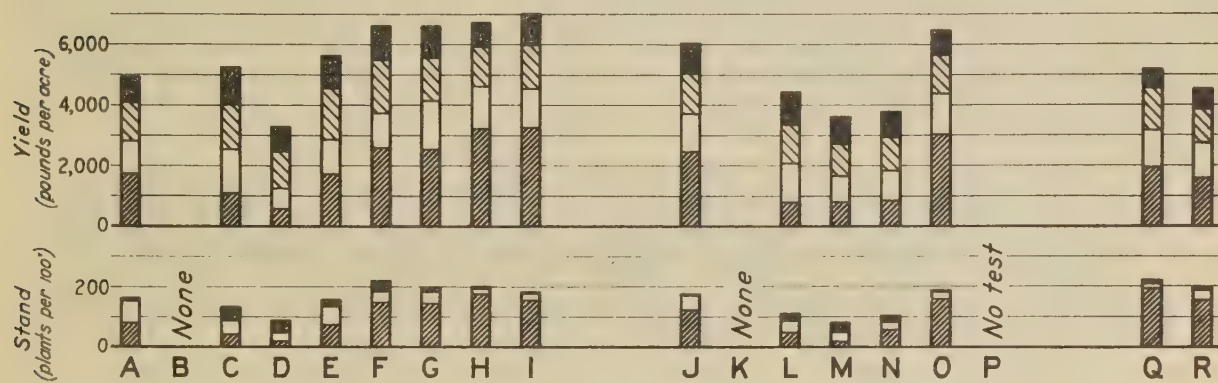


Fig.4

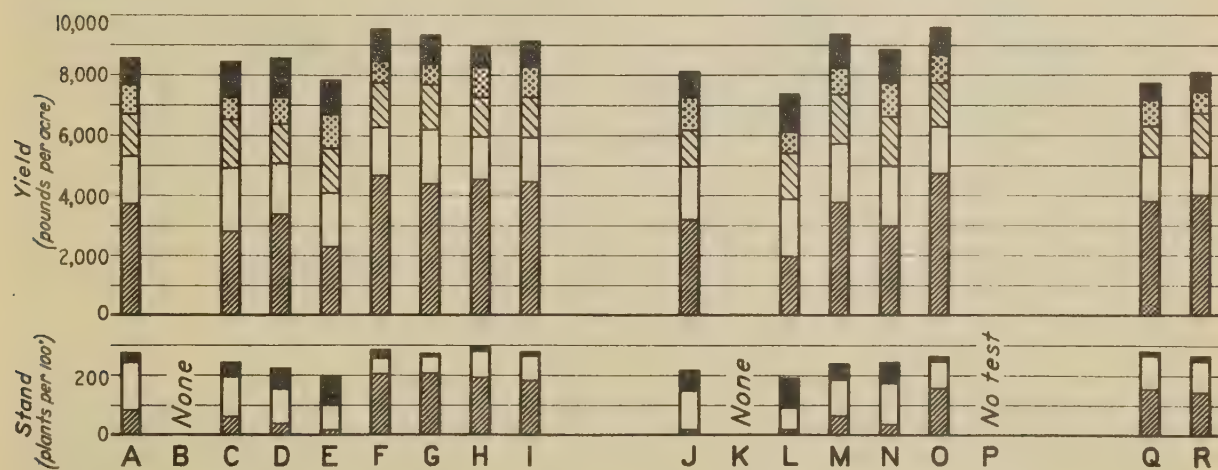


Fig.5

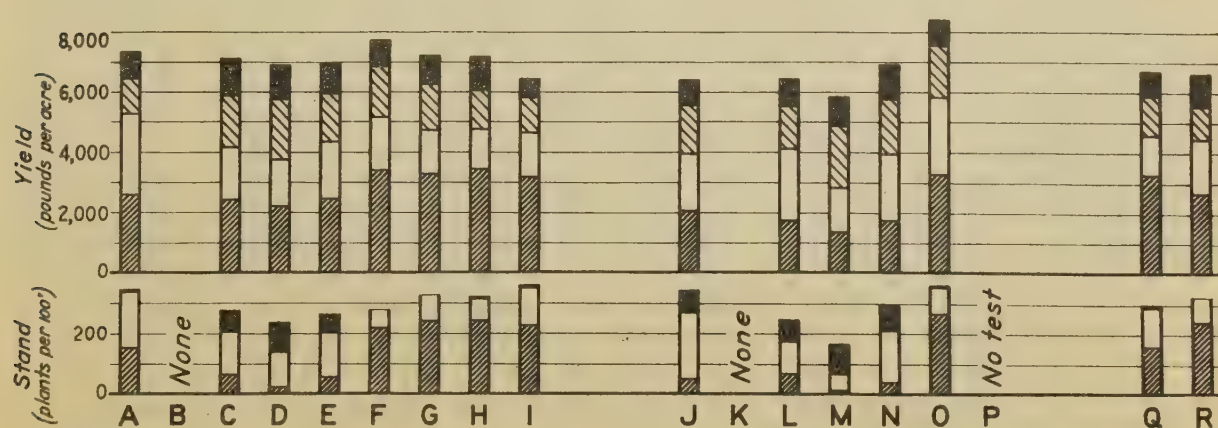


Fig.6



Figure 7.- Effect of different placements of 700 pounds per acre of 5-7-5 fertilizer on stand of beans on Leon fine sand. (a) Fertilizer applied 4 inches to side and 1.5 inches below level of seed; (b) 2 inches to side and 1.5 inches below seed; (c) 1 inch below seed in 3.5-inch band; (d) 3 inches below in 3.5-inch band

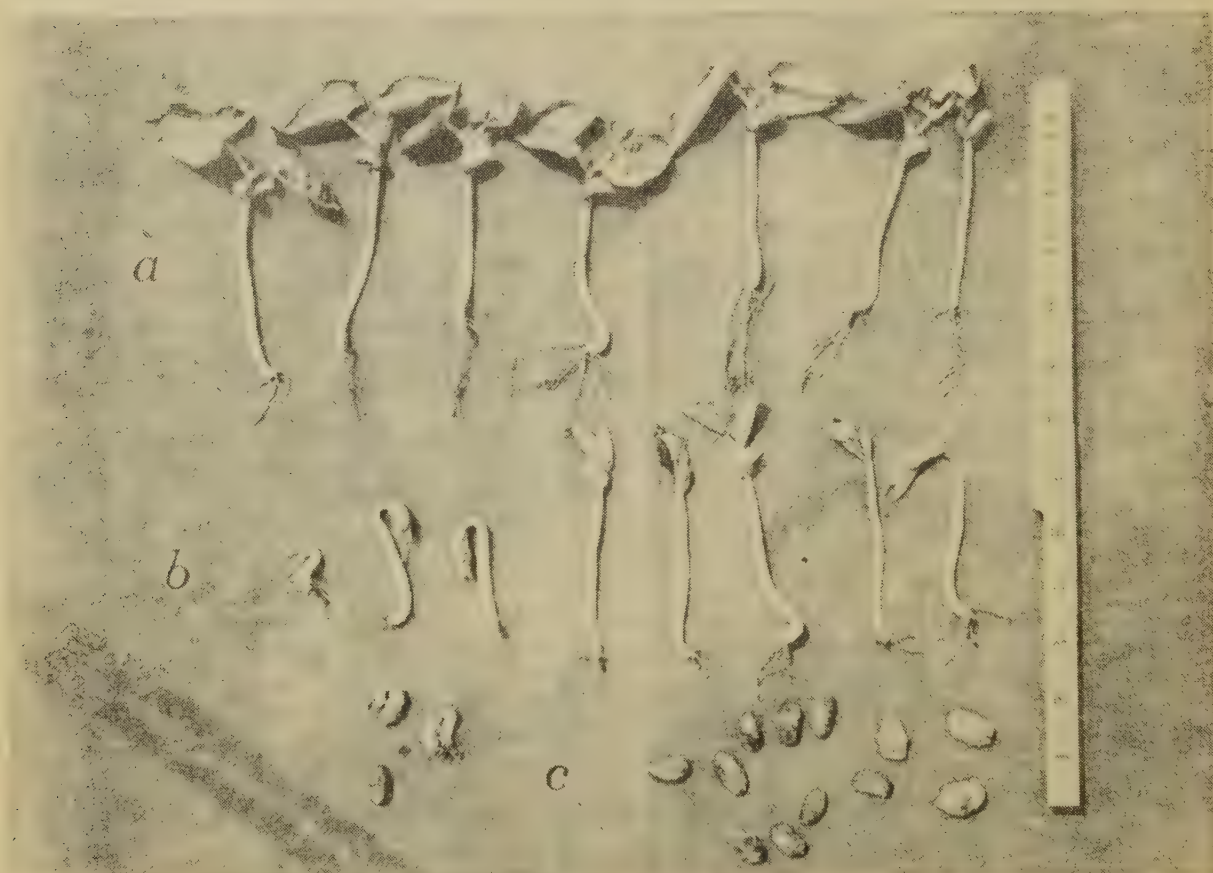


Figure 8.- Typical bean plants dug from plots 7 days after planting when 700 pounds of 5-7-5 fertilizer was applied on Leon fine sand. (a) (Top) Fertilizer placed to side of seed; (b) (Center) Fertilizer placed 1 inch below seed in bands 1.75 inches wide; (c) Fertilizer placed in contact with seed



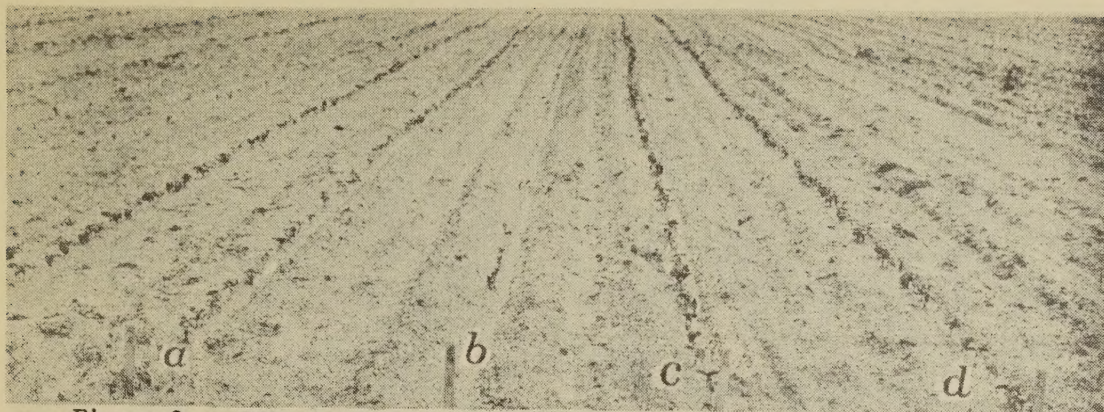


Figure 9.- Effect of different placements of 350 pounds per acre of 10-14-10 fertilizer on stand of beans on Leon fine sand. (a) No fertilizer; (b) fertilizer applied 1 inch below seed in 3.5 inch band; (c) 2 inches to side 1.5 inches below level of seed; (d) 3 inches to side and 1.5 inches below level of seed



Figure 10.- Effect of different placements of 700 pounds of 5-7-5 fertilizer on stand and growth of beans on Leon fine sand. (a) Applied 1 inch below seed in 1.75-inch band; (b) 3 inches below seed in 1.75-inch band; (c) mixed with soil below seed; (d) 3 inches below seed in 3.5-inch band; (e) 1 inch below seed in 3.5-inch band

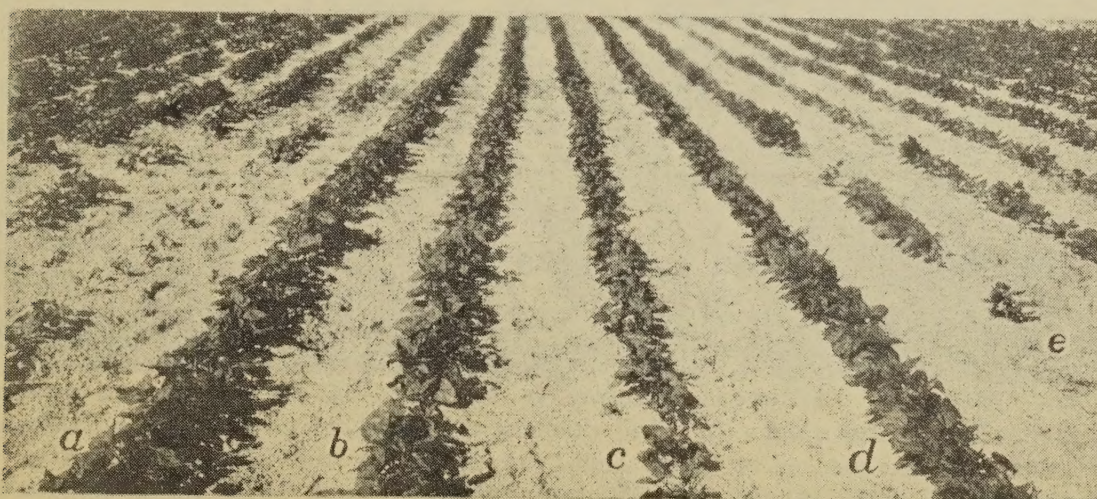


Figure 11.- Effect of different placement of fertilizer on stand and growth of beans on Leon fine sand. 700 pounds of 5-7-5 fertilizer applied (a) On surface of ground above seed; (b) first application, side dressed 7 days after seed planted. 350 pounds of 10-14-10 applied (c) 1 inch below the seed in a 3.5-inch band; (d) 2 inches to side and 1.5 inch below seed level; (e) mixed with soil below seed





Figure 12.- Effect of different placements of 5-7-5 fertilizer on growth of beans on Leon fine sand: 700 pounds per acre of fertilizer applied at planting on a level 1.5 inches below the seed; (a) 2 inches to each side (b) 4 inches to each side and 700 pounds as side dressing 21 days later; (c) no fertilizer applied at planting, 700 pounds per acre applied as a side dressing 7 days after planting and 700 pounds 21 days after planting



Figure 13.- Effect of different placements of 10-14-10 fertilizer on growth of beans on Leon fine sand. (a) 350 pounds of fertilizer applied 2 inches to side and 1.5 inches below seed level at planting and 350 pounds as a side dressing 21 days later; (b) 350 pounds mixed with soil below seed at planting and 350 pounds as a side dressing 21 days later; (c) 350 pounds applied 1 inch below seed in 1.75-inch band at planting and 350 pounds as a side dressing 21 days after planting





